WATER MANAGEMENT IN THE CHANGING BARMAH-MILLEWA WETLANDS

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Rapid and widespread vegetative and faunal composition change is now clearly evident in the Barmah-Millewa wetland system. Alteration to natural flooding regimes, brought about by flow regulation of the River Murray, remains the primary cause. Environmental water allocations serve to assist in alleviating some of the stress to a limited range of biota. A stronger focus on providing additional water resources to the wetlands, and on improving complimentary management actions, is increasingly being applied. Success in achieving some ecological objectives such as successful breeding of colonially-nesting waterbird species and maintaining the extent of the Moira Grass plains are discussed, with some challenging results.

Key words: Barmah-Millewa, wetland, flood regime, River Murray, environmental water allocation

FLOODPLAINS are dynamic, changing environments. The natural rate and direction of change can be highly variable, with biotic and abiotic influences, such as hydraulic regimes interplaying with fluvial dynamics, changing vegetation zonation and habitat availability in space and time (Blanch et al. 1999; Bren & Gibbs 1987; Currey & Dole 1978; Puckridge et al. 1998; Rutherford 1990). However, it is often the departure from 'natural' variability, or even 'desired' variability, and the consequences that this brings to a multitude of human-valued issues on the floodplain, which drives management activities towards stabilising the system, or at least reducing their rate of change.

Altered vegetation zonation, composition, structure or abundance is of concern more than just from potential visual amenity loss. The fracturing of connectivity between healthy wetlands will serve to limit the ability for many aspects of 'natural biodiversity' to rebound from the disturbance (Young 2001).

The Barmah-Millewa wetland system, located on the Murray River floodplain between the townships of Tocumwal, Deniliquin and Echuca, is a substantial reserve exhibiting many characteristics of ecosystem change. The site is experiencing well-documented biodiversity alterations in the face of competing resource demands. Considerable management effort and resources is increasingly being directed towards improving the general ecological health of the area. Some successes in improving the health and viability of various focal, or flagship, species are being experienced, while improvement in knowledge continues to be gained through research, monitoring and adaptive management techniques.

The values and threats to the Barmah-Millewa wetland system will be outlined, strategies identified and management actions highlighted which are part of attempts to maintain this site as one of the very special regional assets.

VALUES

The Barmah wetland system contains examples of at least four of Victoria's eight wetland categories, including some of the state's most depleted wetland types: 15% of the remaining freshwater meadow and 13% of the remaining shallow freshwater marsh in the state (DSE 2003). The site is also recognised under the Convention of Internationally Significant Wetlands (DSE 2003) and is listed on the Register of the National Estate (DEH 2005).

Three waterbird species that occur at Barmah-Millewa are protected under the Japan-Australia Migratory Bird Agreement (JAMBA) and six species under the China-Australia Migratory Bird Agreement (CAMBA). Additionally, 49 fauna species and 32 flora species listed as threatened in Victoria are known to reside in Barmah Forest alone (DSE 2003). Of these, three fauna species and five flora species are listed as threatened in Australia (EPBC 1999, as cited in DSE 2003).

Approximately 400 indigenous species of plants have been recorded in the Barmah reserve alone, with around another 160 species being exotic (DCE 1992; DSE 2003). Most of the exotic species exist as grasses or herbs occurring on disturbed higher ridges within the forest, with the bulk of the wetland biomass represented by indigenous species.

The structure of the forest is different from most other Eucalypt forests that tend to be dominated by two different Eucalypt species. Barmah-Millewa, being representative of the mid-Murray floodplain region, is instead dominated by mono-specific stands of River Red Gum (*Eucalyptus camaldulensis* Dehnh.) as the Red Gum is the only species that can tolerate the duration of flooding and interspersed dry periods that is usually experienced on the floodplain. However, Grey Box (*Eucalyptus microcarpa* Maiden) tends to replace the Red Gum on higher elevated ridges that rarely flood, while Yellow Box (*Eucalyptus melliodora* A. Cunn. ex Schau) occurs on the sandier and freer-draining soils and Black Box (*Eucalyptus largiflorens* F. Muell.) exists in the infrequently flooded wetlands with heavy clay soils.

The other unusual aspect of the forest is that it generally lacks a shrub understorey. Only 40 species in the forest have a tree or shrub habit, hence the vast majority of the species diversity is comprised of forbs and herbs (DCE 1992). Approximately 60 discernable vegetation 'communities' have recently been mapped in the Barmah Forest (Frood *in prep.*), providing detail to the nine Victorian Ecological Vegetation Classes (EVCs) that have been mapped for the site (DSE & GBCMA 2005).

Barmah-Millewa wetlands are renowned for providing important feeding, roosting and breeding areas for a wide variety of waterbird species (Loyn et al. 2002). The wetlands support one of Victoria's largest Australian White Ibis (*Threskiornis aethiopicus* Latham) and Straw-necked Ibis (*Threskiornis spinicollis* Jameson) breeding colonies, with important numbers of Yellow-billed Spoonbill (*Platalea flavipes* Gould) and Royal Spoonbill (*Platalea regia* Gould) also breeding regularly. Various cormorant (*Phalacrocorax* spp.) and egret (*Ardea* spp.) species also bred in small colonies, while a large number of other waterbird species bred more diffusely throughout the wetland system.

The Barmah-Millewa wetlands and their produce are also highly valued for their cultural heritage, recreation, tourism and economic values (DCE 1992; Stone 1991).

THREATS

The primary threat to the environmental values of the Barmah-Millewa wetland system is altered hydrologic regimes. Pest plant and animals, resource utilisation (such as grazing and logging), altered fire regimes and recreation can also play various confounding roles (DCE 1992; DSE 2003; DSE & GBCMA 2005).

Altered flooding patterns from the River Murray began as early as the 1920s when various major irrigation developments began (Jacobs 1990; Thoms 1995). The major impacts for the Barmah-Millewa wetland systems have been the construction of upstream reservoirs that capture the bulk of high winter-spring flows to release for downstream consumptive use primarily in spring-summer. The two biggest impacts arose following the construction of Hume Reservoir in the late-1920s/early-1930s, including increases in capacity in the 1940s, 50s and 60s, and Dartmouth Reservoir in the mid- to late-1970s.

For the Barmah-Millewa wetland system, river regulation has reduced the frequency, duration and inundation area of winter-spring floods, altered the timing of floods, increased the frequency of smaller summer floods, and reduced variability in flood flows (Bren 1987, 1988; Chong & Ladson 2003; Thomson 1993). Alterations to the structure and composition of the vegetation communities, especially the loss of large open plains dominated by Moira Grass (*Psuedoraphis spinescens* (R. Br.) Vickery), have been documented (Bren 1992; Chesterfield 1986; Dexter et al. 1986).

Similar accounts have been recorded from significant reduction in fisheries, waterbird breeding and other faunal elements (such as lower number of snakes, leeches, etc) (Leslie 1995, 2001; King this issue).

STRATEGIES

In response to increasing concern over biodiversity loss and reduced economic, social and cultural values, a range of strategies for improved management of the Barmah-Millewa site have been prepared and progressively implemented (DSE & GBCMA 2005; Young & Mues 1999).

Most effort and advances for the Barmah-Millewa wetlands has been focused on improved water management. Leitch 1988, Ward et al. 1994, CRG 1994, Leslie & Harris 1996, MWEC 1997, BMF 2000, SRP 2003, and DSE & GBCMA 2005 are just a selection of the range of plans and strategies that have all made various contributions to the current water management activities in the forest.

The specific allocation of 100 GL per year of high security water to the Barmah-Millewa wetlands marked a pivotal point in water management history for the forest, especially when first used in 1998 (Maunsell McIntyre Pty Ltd 1999). The subsequent increase in allocation of an additional 50 GL of lower security allocation (statistically available in about 75% of years), with carry-over rules to permit accrual up to 700 GL (MDBMC 2001), means significantly improved opportunities for wetland management in the forest. Although these volumes appear to be large, they represent a small proportion of the river storage and flow. Greater than 90% of the flow returns to the river system after it passes through the Barmah-Millewa wetlands, which means the bulk of the volume is potentially available for irrigation consumptive use downstream.

A suite of specific ecological objectives for the use of environmental water in Barmah-Millewa wetlands continue to be defined (DSE & GBCMA 2005; MDBC *in prep.*), though practice to date has concentrated largely on maintaining suitable breeding conditions for colonially-nesting waterbirds (Webster 2004). Other benefits to Moira Grass plains have also been noted and generally support the flood duration decisions.

APPLICATION

1998 flood

The Barmah-Millewa environmental water allocation was first used in 1998 when 97 GL was provided to supplement a minor spring flood in the forest (Campbell 1998; Maunsell McIntyre Pty Ltd 1999). The release was made in an attempt to prolong the inundation of wetlands following a very short natural flood event in September, the first for 22 months. Although the river peaked at a flow rate of 91 300 ML per day downstream of Yarrawonga, the flood could at best be described as 'thin' in that the hydrograph shows the flood as rapidly rising then falling within a week. Attenuation of the flood peak *en route* to the forest (eg, peaking at 70 500 ML per day at Tocumwal only three days after passing Yarrawonga), and then further attenuation within the forest, meant that the flooding extent in the wetlands reflected a flood of much lesser river peak. However, the subsequent release of environmental water did enable continued low level flooding to occur with flows of around 16 000 ML per day being managed in the river for three weeks.

Unfortunately no follow-up rainfall occurred to replace the need for continued releases of environmental water to maintain the flooding, at which time the water entitlement account was exhausted and hence the special releases stopped. Despite many species of wetland flora and fauna responding beneficially towards the 1998 enhanced flood event, the period of inundation and depth was insufficient to achieve all of the desired ecological objectives (Maunsell McIntyre Pty Ltd 1999).

2000-01 flood

The second use of the environmental water allocation was in spring 2000, extending into mid-summer of January 2001, when a total of 341 GL was provided from a range of environmental water accounts to supplement a series of large spring flooding events in the forest (BMF 2001; Maunsell McIntyre Pty Ltd 2001). The first natural flood arose in late September from the Ovens River catchment and when added to Hume Reservoir pre-releases produced a peak downstream of Yarrawonga of 68 000 ML per day. The second natural flood peak occurred in November from the Hume catchment and resulted in a peak outflow downstream of Yarrawonga Weir of 88 000 ML per day. Both peaks were associated with 'fat' floods, as the hydrograph shows the peaks to be associated with prolonged flooding flows (i.e., occurring for long enough to cause natural overbank flows to persist for months). The environmental water was released and managed in various parcels to reduce the rate of recession in the river flows and thereby prolong inundation of the wetlands of Barmah-Millewa (Fig. 1).

This type of active water management approach is locally known as filling 'holes' in the river, and is employed to slow the recession of floods that river regulation now otherwise causes to recede more rapidly and frequently than under natural conditions. The major aim of slowing the recession of flooding is often to prevent breeding waterbirds from abandoning their nests if wetland flooding were to sharply subside.

The water management actions undertaken in 2000-01 represented the largest release of environ-

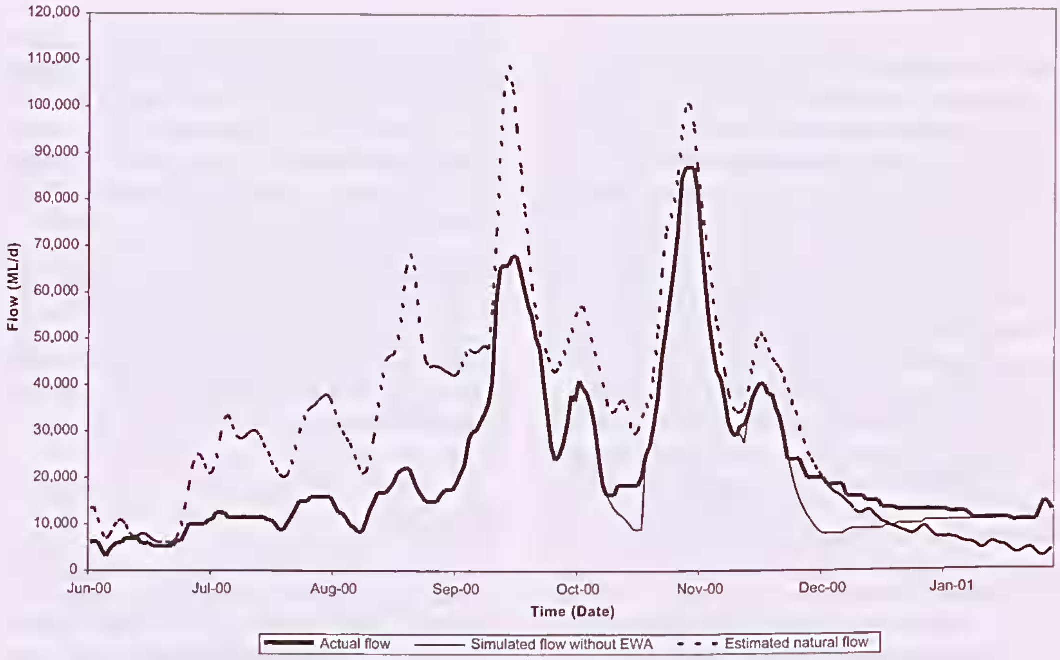

Fig 1. River Murray flows downstream of Yarrawonga Weir, June 2000 to January 2001.

mental water yet made in Australia, and supplemented a one in five year flood event. The timing and management of the environmental water allocation yielded the best waterbird breeding outcome for many years, being more reflective of a one in ten year event, with some waterbird species having breed in the wetlands for the first time in 20 years (Leslie & Ward 2002). A similarly good result was found to occur from monitoring projects being undertaken at the time on fish, frogs and vegetation in the flooded region (BMF 2001; Ward 2001).

The use of the environmental water allocation in 2000-01 also highlighted a range of water management issues that continue to challenge natural resource managers. Supplying environmental water allocations at the desired times and volumes for the Barmah-Millewa wetlands will often necessitate exceeding river channel capacity downstream of Hume Reservoir, and hence flooding some low lying freehold pastoral land. In the 2000-01 flood event, the Murray-Darling Basin Commission (MDBC) authorised over-bank flows in the Hume to Yarrawonga reach for some days in late November and early December during a period of coincident high irrigation demands at Yarrawonga and high EWA flows for the Barmah-Millewa wetlands. Retrospective compensation in the form of *ex gratia* payments for some affected landholder claims were made following the 2000-01 event (BMF 2001; Maunsell McIntyre Pty Ltd 2001). Most of the initial claims were for inundation and loss of grazing feed, interrupted access, forced sale of stock, interrupted bridge construction and loss of passing trade, though the major dollar payments on this occasion were made for the later two issues (Maunsell McIntyre Pty Ltd 2001).

Acquisition of a flood easement over the land between Hume Reservoir to Yarrawonga Weir is currently being negotiated to confirm the MDBC's right to pass flows up to 25 000 ML per day, with the intent of The Living Murray Initiative to investigate greater flood easements in the 25 000-45 000 ML per day range for environmental flow delivery (B. Campbell *pers. com.*). Acquisition of the higher easements of at least 40 000 ML per day will be required to achieve many of the ecological objectives that have been set for the downstream wetlands, though this may be some time off, if at all. As such, unless 'compensation' is again to be paid for managed environmental flooding, only the lowest lying sections of the Barmah-Millewa wetlands can be targeted for environmental water allocations.

The 2000-01 flood event also highlights the critical importance of the largely unregulated Ovens and Kiewa River catchments upstream of the Barmah-Millewa wetlands. The frequency, depth and duration of flood events experienced by the floodplain from the Kiewa outfall to the Barmah Choke would be further diminished if these two catchments were ever to be regulated. It therefore remains a strong imperative to ensure that both the Ovens and Kiewa catchments remain 'open'.

Although the Barmah-Millewa environmental water allocation has not yet been used since 2000-01, the annual allocation of water continues to accumulate in storage until required, either when triggered by particular flow events or called upon by state agency resource managers for special environmental purposes, or it can be spilled from storage if Hume Reservoir overflows (MDBMC 2001). The current volume that has been accrued and now available for use in Barmah-Millewa wetlands is 500 GL, with release likely to be next year unless triggered in the interim (and depending upon pay-back rules associated with the current loan of a volume of the accrued environmental water allocation to NSW irrigators) (NRE 1999; MDBMC 2001).

Other water management activities can and do occur in the absence of formal releases of environmental water allocations. All 'seasonal' (winter-spring) flows exceeding channel capacity through Barmah-Millewa are directed to wetland environments where most required. 'Unseasonal' (summer-autumn) flows are generally managed away from sensitive wetland environments that are otherwise meant to be experiencing natural dry cycles.

2002 event

Very occasionally, the opportunity exists to pass high irrigation level flows through restricted areas of the forest by agreement with River Murray Water. One such event occurred in the spring of 2002 during a transfer of large volumes of water from Hume Reservoir to Lake Victoria near the South Australian boarder due to continuing drought conditions and the need to maintain water supply to the lower Murray system, including Adelaide (O'Connor & Ward 2003). At the time there were high irrigation demands, which meant the channel flow was at bank full so the additional water spilled into the low laying topography of the Barmah-Millewa environment and passed through selected Barmah Forest waterways that outfall back into the river channel downstream of the Barmah Choke (O'Connor & Ward 2003; Abuzar & Ward 2003).

A predicted colonial bird breeding event occurred because of the suitable constant low-level flooding through the traditional breeding sites, despite the otherwise drought conditions in the region. Although the higher level transfers were concluded by early December 2002, appropriate ponding levels were maintained by supplying targeted low flows into early February until the colony of predominantly Australian White Ibis and Royal Spoonbill successfully fledged (O'Connor & Ward 2003).

Although targeted water management activities have achieved some good waterbird breeding results over the past decade, other breeding attempts have been known to fail due to premature flood subsidence or lack of appropriate flooding (O'Connor & Ward 2003; Webster 2004). Furthermore, modelling of various waterbird breeding preferences by Leslie (2001) shows that there exists very probable local breeding extinctions of some species (such as egrets) as a result of reduced flooding regimes. Channel capacity constraints, and inadequate volumes of environmental water, mean that the required flood regimes can often not be achieved.

Alterations to the composition, health and distribution of various vegetation communities continue to occur in the Barmah-Millewa wetlands (personal observation, with photographic evidence). Most apparent is the continued reduction in extent of Moira Grass plains from encroachment by River Red Gum and Giant Rush (*Juncus ingens* N.A.Wakef.), despite stated management aims and actions intended to prevent this from occurring (Ward et al. 1994; CRG 1994; MWEC 1997; NRE 1999; BMF 2000; SRP 2003; and DSE & GBCMA 2005). Detailed mapping of the understorey vegetation in the forest is nearing completion, and combined with other analysis of available information, is expected to permit a refined ability to document and monitor vegetation response trends.

THE FUTURE?

Improved water management and coordinated complimentary management actions continue to be strengthened (DSE & GBCMA 2005; GBCMA 2003). The introduction of water reforms in Victoria (DSE 2004) and the MDBC's Living Murray Initiative (MDBC 2004) provides some promise towards improving the future of wetland environments such as Barmah-Millewa. This will mainly be achieved via increased opportunities for improved environmental water management within the existing regulated systems, the provision of additional water volumes, and funding to support better infrastructure, research and monitoring programs to facilitate better environmental outcomes. However, much more is required, especially with continuing drought conditions and forecast green-house impacts of reduced rainfall for this region (DSE 2005).

A precautionary approach to natural resource management has to be undertaken (Rogers et al. 1997). Trends of diminishing environmental values within the Murray-Darling Basin and beyond are numerously reported, with few contradictory records. If we cannot get wetland management right in such a 'relatively' easily-managed location as Barmah-Millewa, which in itself represents a small fraction of the natural wetland estate, then few alternative sites exist. The management decisions and actions we make today are vitally important.

Maintaining caps on water diversions, increasing volumes of environmental water allocations, enabling higher level flood easements, reducing unseasonal flooding, conducting additional research and monitoring programs, providing appropriate resource allocations, undertaking complimentary management actions, and gaining broad community and scientific support, are all required if healthy sustainable wetland biodiversity and functioning is to be maintained. The challenge is already being accepted in many ways.

REFERENCES

Abuzar, M. & Ward, K.A., 2003. Flood and vegetation mapping in the Barmah-Millewa Forests during October-December 2002 using remote sensing technology. Report prepared for the Barmah-Millewa Forum. Department of Primary Industries, Tatura.

Blanch, S.J., Ganf, G.G. & Walker, K.F., 1999. Tolerance of riverine plants to flooding and exposure indicated by water regime. *Regulated Rivers: Research and Management* 15: 43-62.

BMF, 2000. Barmah-Millewa Forest Water Management Strategy. Barmah-Millewa Forum for Murray-Darling Basin Commission, Canberra.

BMF, 2001. Water management in the Barmah-Millewa Forest: Annual report 2000-01. Barmah-Millewa Forum for Murray-Darling Basin Commission, Canberra.

Bren, L.J., 1987. The duration of inundation in a flooding River Red Gum Forest. *Australian Forestry Research* 17: 191-202.

Bren, L.J., 1988. Flooding characteristics of a riparian red gum forest. *Australian Forestry* **51**: 57-62.

Bren, L.J., 1992. Tree invasion of an intermittent wetland in relation to changes in the flooding frequency of the River Murray, Australia. *Australian Journal of Ecology* 17: 395-408.

Bren, L.J. & Gibbs, N.L., 1987. Relationships between flood frequency, vegetation and topography in a river red gum forest. *Australian Forestry Research* 16: 357-370.

Campbell, B., 1998. Operational Assessment of watering the Barmah-Millewa Forest using an environmental allocation. Technical Report 98/4, Murrary-Darling Basin Commission, Canberra.

Chesterfield, E.A., 1986. Changes in the vegetation of the river red gum forests at Barmah, Victoria. *Australian Forestry Research* 49: 16-27.

Chong, J. & Ladson, A.R., 2003. Analysis and management of unseasonal flooding of the Barmah-Millewa Forest. *River Research and Applications* 19: 161-180.

CRG, 1994. Final Report on Barmah-Millewa Forest Water Management Plan from a local Community Reference Group. Murray-Darling Basin Commission, Canberra.

Currey, D.T. & Dole, D.J., 1978. River Murray flood flow patterns and geomorphic tracts. *Proceedings of the Royal Society of Victoria* 90: 67-77.

DCE, 1992. Barmah Management Plan: Barmah State Park & Barmah State Forest. Department of Conservation and Environment, Victoria.

DEH, 2005. Australian Heritage Database. Department of Environment and Heritage, Canberra.

Dexter, B.D., Rose, H.J. & Davies N., 1986. River regulation and associated forest management problems in the River Murray red gum forests. *Australian Forestry Research* 49: 16-27.

DSE, 2003. Barmah Forest Ramsar Site: Strategic Management Plan. Department of Sustainability and Environment, Melbourne.

DSE, 2004. Victorian Government White Paper: Securing our water future together. Department of Sustainability and Environment, Melbourne.

DSE, 2005. Victorian greenhouse strategy action plan update. Department of Sustainability and Environment, Melbourne.

DSE & GBCMA, 2005. Asset Environmental Management Plan: Barmah Significant Environmental Asset, 11 May 2005. Department of Sustainability and Environment, Benalla, and Goulburn Broken Catchment Management Authority, Shepparton.

Frood, D., *in prep.* Mapping of the understorey vegetation in Barmah Forest. Pathways Experiences for Department of Sustainability and Environment, Tatura.

GBCMA, 2003. Goulburn Broken Regional Catchment Strategy. Goulburn Broken Catchment Management Authority, Shepparton.

Jacobs, T., 1990. Regulation and management of the River Murray. In *The Murray*, N. Mackay & D. Eastman, eds, Murray-Darling Basin Commission, Canberra, 39-58.

Leitch, C., 1988. Towards a strategy for managing the flooding of Barmah Forest. Department of Conservation Forests and Lands, Benalla, Victoria.

Leslie, D.J., 1995. Moira Lake: A case study of the deterioration of a River Murray natural resource. Thesis submitted for Master Forest Science, University of Melbourne.

Leslie, D.J., 2001. Effect of river management on colonially-nesting waterbirds in the Barmah Millewa Forest, South Eastern Australia. *Regulated Rivers: Research and Management* 17: 21-36.

Leslie, D. & Harris, K., 1996. Water Management Plan for the Millewa Forests. State Forests of NSW and Dept of Land and Water Conservation, NSW.

Leslie, D.J. & Ward, K.A., 2002. River Murray environmental flows 2000-2001. *Ecological Management & Restoration* 3: 221-3.

Loyn, R.H., Lumsden L.F. & Ward K.A, 2002. Vertebrate Fauna of Barmah Forest, a Large Forest of River Red Gum *Eucalyptus camaldulensis* on the Floodplain of the Murray River. *The Victorian Naturalist* 119: 14-32.

Maunsell McIntyre Pty Ltd, 1999. Report on Barmah-Millewa flood of October 1998 and the first use of Barmah-Millewa allocation. A report prepared for the Barmah-Millewa Forum and Murray-Darling Basin Commission, Canberra, 121 pp.

Maunsell McIntyre Pty Ltd, 2001. Report on Barmah-Millewa Forest flood of spring 2000 and the second use of Barmah-Millewa Forest environmental water allocation, spring-summer 2000-01. A report prepared for the Barmah-Millewa Forum and Murray-Darling Basin Commission, Canberra, 127pp.

MDBC, 2004. Living Murray Business Plan, 26 November 2004. Murray-Darling Basin Commission, Canberra

MDBC, *in prep.* Asset Environmental Management Plan: Barmah-Millewa Significant Environmental Asset. Murray-Darling Basin Commission, Canberra.

MDBMC, 2001. Interim operating rules and triggers for the use of the Barmah-Millewa Forest Environmental Water Allocation. Murray-Darling Basin Ministerial Council, Canberra.

MWEC, 1997. Sharing the Murray: Proposal for defining people's entitlements to Victoria's water from the Murray. Murray Water Entitlement Committee, Victoria.

NRE, 1999. Entitlements to the Murray: Outcomes of work to define how Victoria's River Murray water is to be shared. Department of Natural Resources & Environment, Melbourne.

O'Connor P.G. & Ward K.A., 2003. Waterbird Monitoring in Barmah Forest, 2002-2003. Department of Sustainability and Environment, Tatura, Victoria.

Puckridge, J.T., Sheldon, F., Walker, K.F. & Boulton, A.J., 1998. Flow variability and the ecology of large rivers. *Marine and Freshwater Research* 49: 55-72.

Rogers, M.F. Sinden, J.A. & De Lacy T., 1997. The Precautionary Principle for environmental management: A defensive-expenditure application. *Journal of Environmental Management* 51: 343–360.

Rutherford, I., 1990. Ancient river, young nation. In *The Murray*, N. Mackay & D. Eastman, eds, Murray-Darling Basin Commission, Canberra, 17-36.

SRP, 2003. Ecological assessment of environmental flow reference points for the River Murray System, interim report. Scientific Reference Panel for the Living Murray Initiative, Murray-Darling Basin Commission, Canberra.

STONE, A., 1991. Economic evaluation of wetlands. Wetland Conservation Report Series, no. 1, Department of Conservation and Natural Resources, Melbourne.

THOMS, M.C., 1995. The impact of catchment development on a semiarid wetland complex: the Barmah Forest, Australia. In *Man's influence on freshwater ecosystems and water use*, G. Petts, ed., International Association of Hydrological Sciences.

THOMSON C., 1993. The impact of river regulation on the natural flows of the Murray-Darling Basin. Technical Report 92/5.2., Murray-Darling Basin Commission, Canberra.

WARD, P.A., 2001. Monitoring frog response to flooding in Barmah Forest, 2000-01. Final report to Barmah-Millewa Forum for the Murray-Darling Basin Commission, Canberra.

WARD, K.A., LEITCH, C., LLOYD, L.N. & ATKINS, B.A., 1994. Interim water management strategy for Barmah Forest, Victoria. Integrated Watering Strategy Report No. 12, Department of Conservation & Natural Resources, Shepparton.

WEBSTER R., 2004. The Effect of Flooding on Waterbirds within Barmah-Millewa Forest, 1999-2003. Ecosurveys Pty Ltd, Deniliquin.

YOUNG, D. & MUES, C., 1999. An evaluation of water management strategies in the Barmah-Milewa forest. ABARE conference paper 93.1, Australian Bureau of Agricultural and Resource Economics, Canberra.

YOUNG, W.J. (ed.), 2001. *Rivers as Ecological Systems: The Murray-Darling Basin*. Murray-Darling Basin Commission, Canberra.